Integrated Food Safety Impacts For Project:

MINIMIZING THE RISK OF *LISTERIA MONOCYTOGENES* AND OTHER PATHOGENS IN DRIED FOODS

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Knowledge to Go Places

OBJECTIVES

- Assess methods used to dry foods in U.S.
- Assess survival of *Listeria monocytogenes*, *Escherichia coli* O157:H7, and *Salmonella* during home-drying foods with methods recommended by Cooperative Extension.
- Develop effective pre-drying processes and procedures.
- Assess fate of pathogens surviving the drying process.
- Conduct taste panels to assess product acceptability.
- Rewrite extension bulletins on home-drying.
- Publicize and teach new methods, assess adoption of recommendations.

OUTCOMES

- Cooperative Extension has traditionally conducted home food preservation training, but home drying has not been considered a food safety issue.
- Our work showed that pathogens could survive the recommended drying processes and that modifications were needed in home drying methods.
- We developed modifications in drying processes to achieve consistent and extensive pathogen inactivation.
- We published and disseminated the modifications.

OUTCOMES

- **Presentations at Professional Meetings: 43**
  - **IFT: 16**
  - **IAFP: 21**
  - **Other: 6**
- **Referred Journal Papers: 26**
  - **J. Food Protection: 9**
  - **Food Microbiology: 5**
  - **Int. J. Food Microbiol.: 4**
  - **J. Food Safety: 2**
  - **Appl. Environ. Microbiol.: 1**
  - **Other: 5 (JFS, LAM, LWT, JFQ, FPT)**

OUTCOMES

- **Research Reports: 7**
- **Fact Sheets: 6**
- **Seminars: 10**
- **Corresponding Course: 1**
- **Web Page: 1**
- **News Releases: 1**
- **M.S. Graduates: 6**
- **Ph.D. Graduates: 2**
- **Postdoctoral Fellows: 6**

OUTCOMES

- **Workshops:**
  - Developed, piloted and now offer a research-based train-the-trainer program on Safe Food Drying at Home.
  - In 2004, the workshop was presented to 6 groups of extension educators and volunteers (n=75).
  - Knowledge and attitude scores regarding safe food drying methods improved ($p<0.05$) from pre- to 6-weeks after workshops.
  - Participants also indicated improvements in food drying practices at the 6-week follow-up.
  - The audience targeted was not new to Cooperative Extension (home food preservers), but the message was.

OUTCOMES

- **Seminars:**

- "Improving the Safety of Home Dried Foods – Research Enhancing Practice," May 3, 2005, Morgan County CSU Alumni Banquet, Fort Morgan, CO, 80 attended.

- "Food Safety Update," Master Food Preservers training, April 6, 2004, Larimer County Fairgrounds, Loveland, CO, 50 attended.

- Food Safety Update and Food Drying Workshop," Master Food Preservers Training, April 28, 2004, Colorado Springs, CO, 45 attended.

OUTCOMES

- What's new in safe home preservation, Master Food Preservers training, April 3, 2003, Loveland, CO. 50 attended.
- Update on safe home food preservation, Master Food Preservers training, April 4, 2002, Loveland, CO. 45 attended.
- "Interdisciplinary Studies Program in Food Science and Safety" Plant Science seminar series, November 13, 2003 – 20 attended.
- "Food Safety Issues," Guest Lecture for LSCC101, 60 attended.

OUTCOMES

- "Food Safety Issues for Consumers, Ohio State University Interactive Video Conference lecture on Food Safety for Consumers, April 10, 2001.
- "*E. coli* and the American Diet," Guest Lecture, PS 492 October 12, 2000 50 attended.
- "Putting Knowledge to Work: Successful Models of Food Safety Education with High-risk Audiences," American Dietetic Association Annual Meeting, October 19, 2000, Denver, CO. 50 attended.

OUTCOMES

- **New guidelines, procedures:**
  - DiPersio, P.A., Kendall, P.A., and J.N. Sofos. 2004. Drying foods: dehydrating fruits, vegetables, leathers and jerkies. Colorado State University Cooperative Extension Bulletin No. 575A. Colorado State University, Fort Collins, CO. 20 p.
  - Three fact sheets on home food drying are cited and linked to from the National Home Food Preservations website maintained at the University of Georgia.

OUTCOMES

- **Regulatory:**
  - Two of our refereed journal publications have been cited in the USDA/FSIS "*Compliance Guideline for Meat and Poultry Jerky Produced by Small and Very Small Plants*" (December 2004). http://www.fsis.usda.gov/PDF/Compliance_Guideline_Jerky.pdf

OUTCOMES

- **Other Outcomes:**
  - Interdisciplinary Studies Program in Food Science/Safety
  - Certificate program offered at the undergraduate and graduate level by 7 departments in 3 colleges.
  - To date, 26 students have participated in the program.
  - Developed a 1-credit seminar in Food Science/Safety that has been offered three times with 6-8 students attending each time offered.
  - Existing courses (AN460-Meat Safety, AN567-HACCP Meat Safety, AN660-Issues in Meat Safety) were updated to include material based on the knowledge generated through this project.

OUTCOMES

- **Integration:**
  - The integration aspect of our project was excellent.
  - Started with a needs assessment of all the food drying recommendations and bulletins offered through Cooperative Extension in the U.S.
  - Systematically evaluated the microbiological efficacy of home drying treatments for jerky, fruits and vegetables
  - Developed modified methods that result in safe and palatable products.
  - Developed educational materials and training programs to teach the modified methods to extension agents and master food preservers

TABLE 1. *Recommended preparation, pretreatments, and drying conditions for tomatoes*[a]

State	Peel	Blanch	Cut or slice	Drying		Organic acid[b]	
				Temp (°C)	Time (h)	Ascorbic[c]	Citric
Colorado	—	Yes	Slice, ½ in. thick; cut, ¾ in. thick	—	—	1–2½ T[b]	2½ T
California	Yes	Yes	Cut, ¾ in. thick or in half	60	10–18	—	—
Florida	—	Yes	Cut, ¼ slices	60	6–8	—	—
Georgia	—	—	—	—	—	2 t	—
Idaho	—	—	—	—	—	½ t	½ t
Illinois	—	—	—	—	—	¼ t	—
Kansas	Yes	—	Slice, ⅛ slices	63	10–12	—	—
Minnesota	—	—	Slice, crosswise ¼ in. thick	60–63	6–8	½ t	¾–1½ t
Mississippi	—	—	—	—	—	2½ T	—
Missouri	Yes	Yes	Slice, ¾ in. thick, cut in half	—	10–18	—	—
Montana	—	—	—	—	—	2 t	—
New Mexico	—	—	—	—	—	2½ T	—
Oregon	—	—	—	—	—	½ t	½ t
Pennsylvania	—	—	—	—	—	½ t–1 T	½ t
South Carolina	—	—	—	—	—	2 t	—
Utah	Yes	Yes	Cut sections about ¾ in. thick in half	—	—	2½ T	—
Virginia	—	—	—	—	—	1 T	—
Washington	—	—	—	—	—	½ t	½ t

[a] Information on home fruit drying compiled from U.S. Cooperative Extension Services. Dash indicates no recommendation given.
[b] t, teaspoon (4.5 g); T, tablespoon (13.5 g). Solution concentration is amount per 1 qt (0.95 liters) of water.

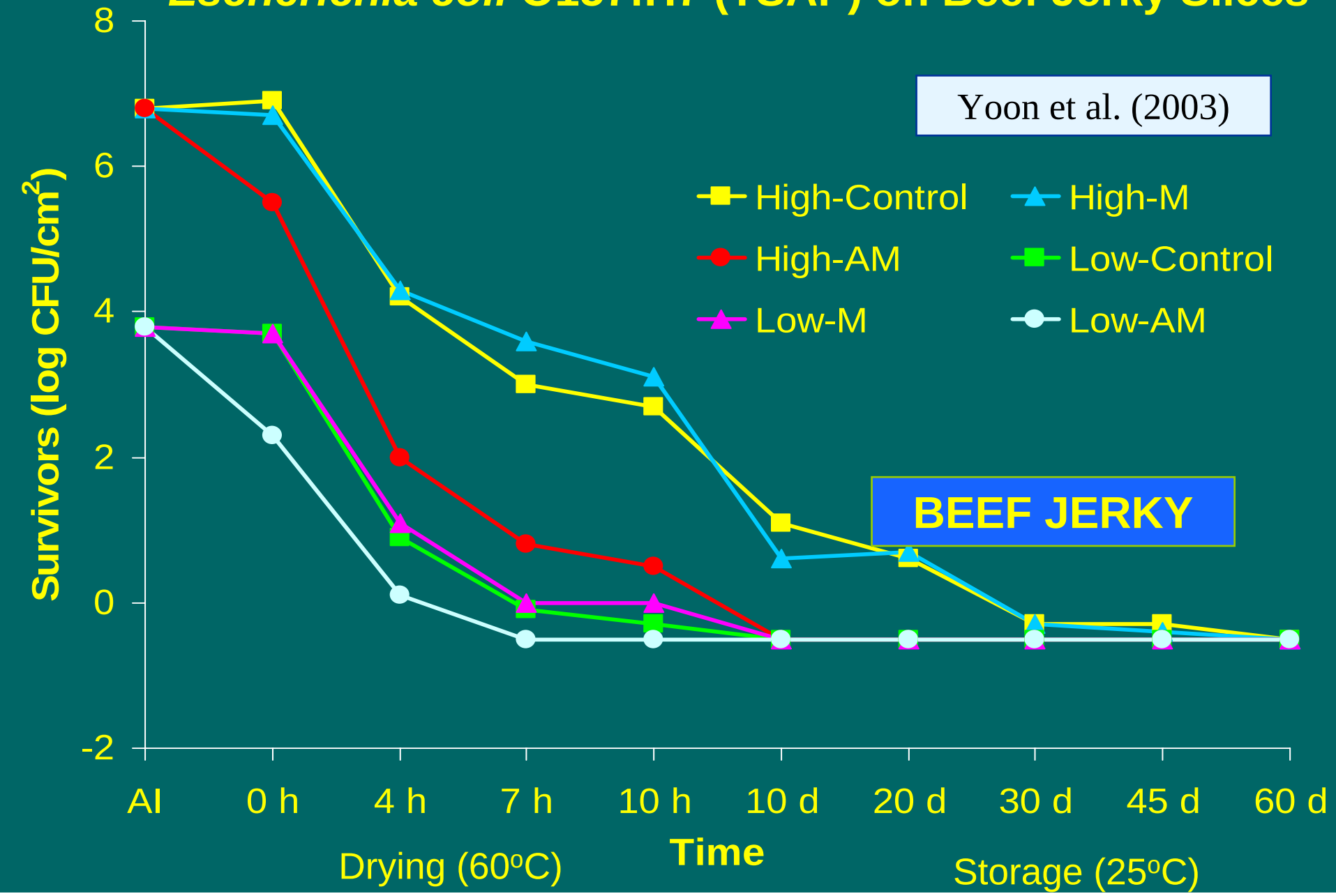
TABLE 1. *Ascorbic acid, citric acid, and sodium metabisulfite antidarkening solution concentrations recommended by U.S. Cooperative Extension Services for home-dried apples*[a]

State(s)	Recommended concn (per qt of water) of[b]:		
	Ascorbic acid	Citric acid	Sodium metabisulfite
Alaska, Florida	*	**	*
California	**	**	*
Colorado	4–10 t	**	1–2 T
Georgia, South Carolina	2 t	**	2 T
Idaho, Oregon, Pennsylvania, Washington	½ t	*	1–3 t
Illinois	¼ t	–1½ t	¼–1½ t
Minnesota	½ t	**	1 T
Mississippi	2½ T	**	**
Missouri, Kansas	¼ t	**	¼ t
Montana	2 t	**	*
New Mexico	2½ T	**	1 T
Ohio	*	**	**
Virginia	1 T	**	**
Utah	2½ T	**	2 T

[a] Information compiled from 20 sets of U.S. Cooperative Extension Service home fruit-drying recommendations. The Indiana, Nevada, New Jersey, North Carolina, North Dakota, Rhode Island, and Wyoming Cooperative Extension Services reported that they neither published nor distributed fruit-drying recommendations.

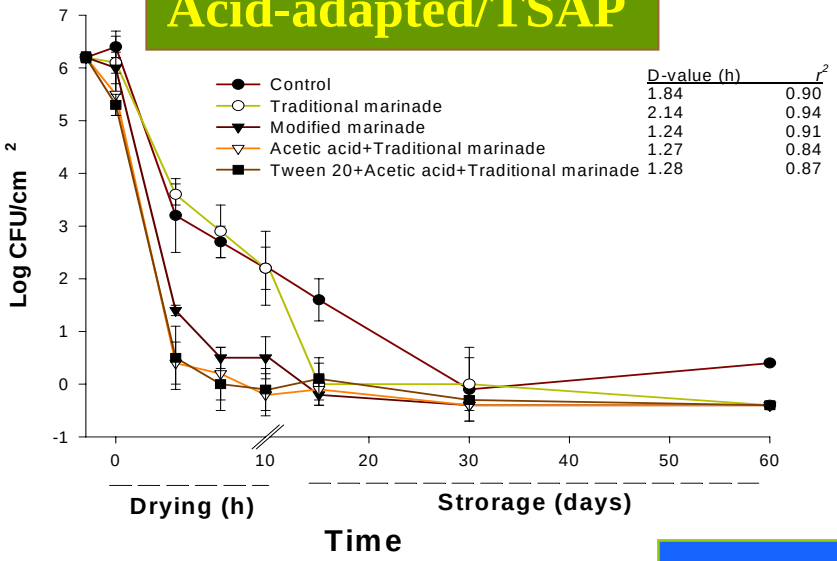
[b] *, recommended without specific concentrations; **, no recommendation given; T, tablespoon (13.5 g of ascorbic acid, 13.5 g of citric acid, 21 g of sodium metabisulfite); t, teaspoon (4.5 g of ascorbic acid, 4.9 g of citric acid, 7 g of sodium metabisulfite).

Escherichia coli O157:H7 (TSAP) on Beef Jerky Slices

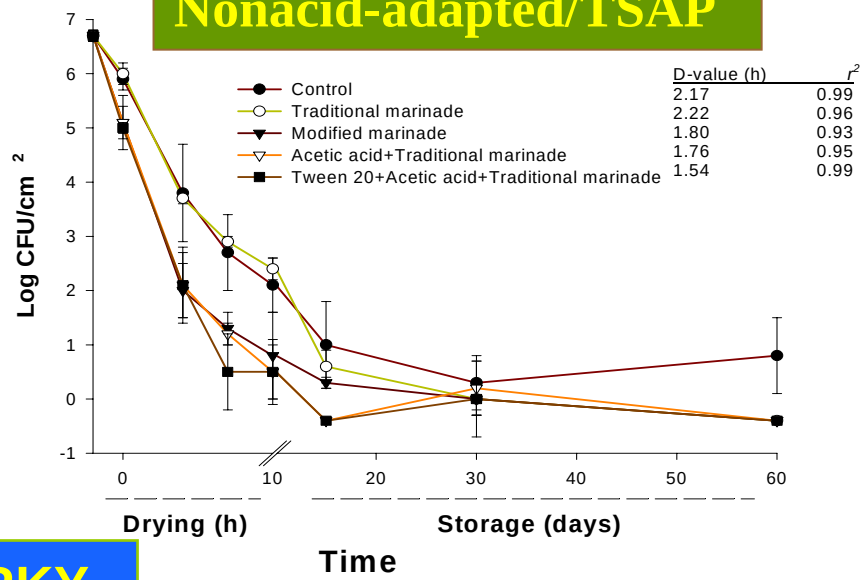


Listeria monocytogenes

Acid-adapted/TSAP

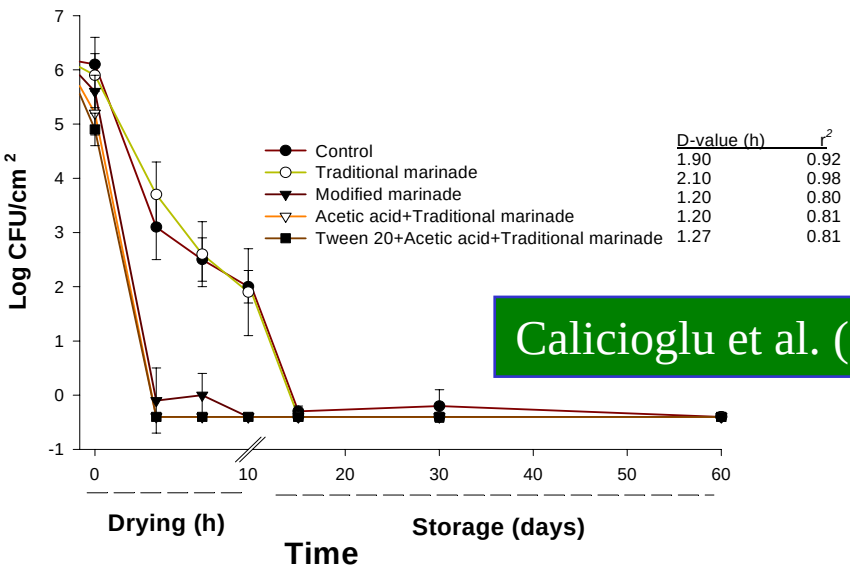


Nonacid-adapted/TSAP



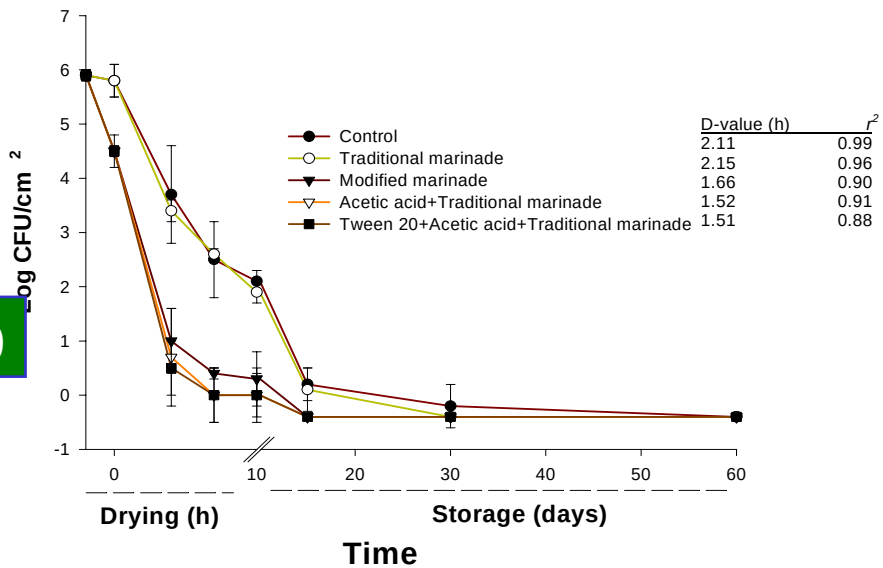
BEEF JERKY

Acid-adapted/PALCAM



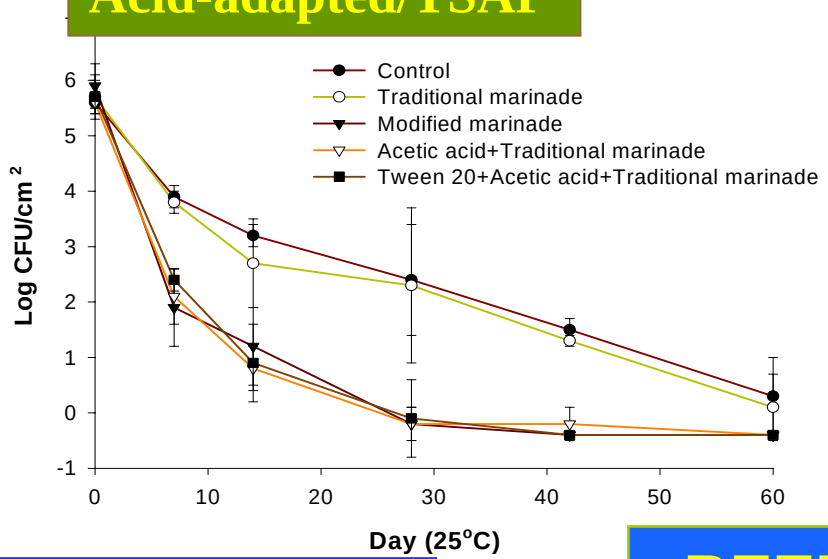
Calicioglu et al. (2002)

Nonacid-adapted/PALCAM

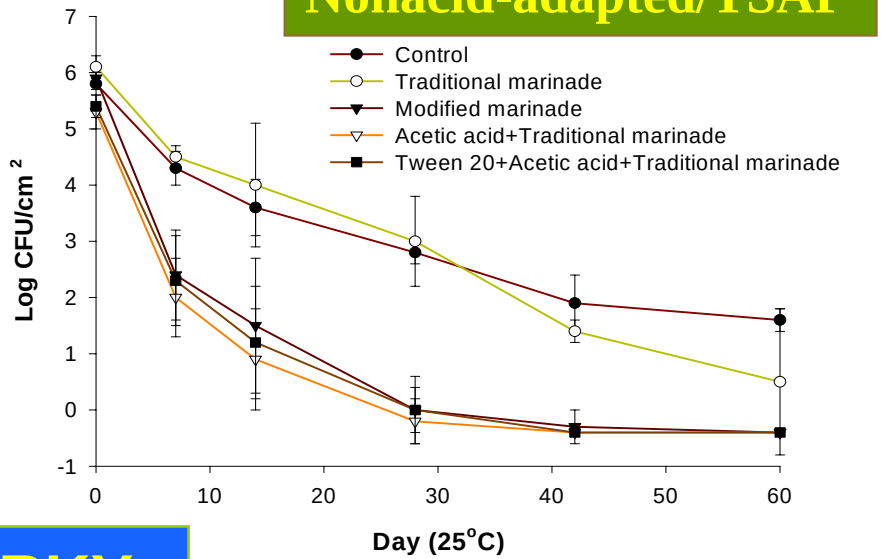


Listeria monocytogenes

Acid-adapted/TSAP



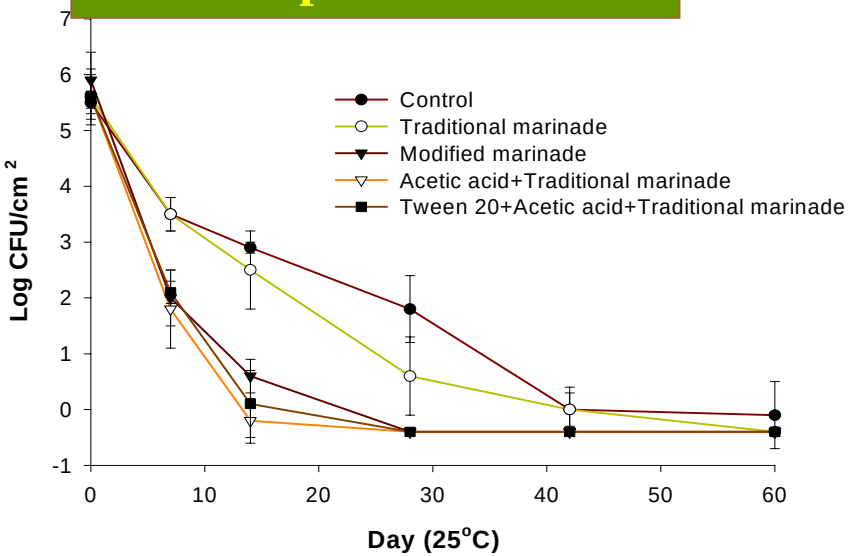
Nonacid-adapted/TSAP



Calicioglu et al. (2002)

BEEF JERKY

Acid-adapted/PALCAM



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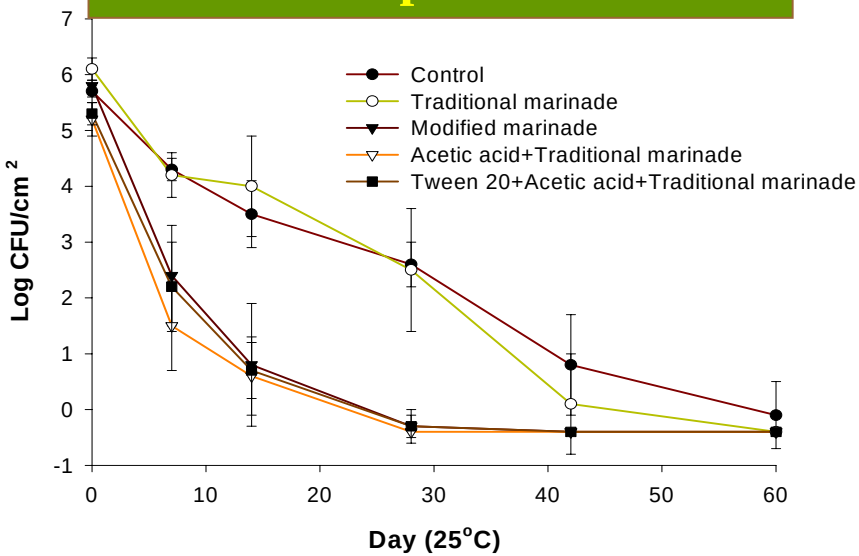


D-Values (h) of *Escherichia coli* O157:H7, *Salmonella* and *Listeria monocytogenes* (TSAP) on Beef Jerky Dried at 60°C for 10 h

Treatment	*Escherichia coli* O157:H7		*Salmonella*		*Listeria monocytogenes*	
	NA	AA	NA	AA	NA	AA
C	2.2	2.2	3.3	2.0	2.2	1.8
TM	2.6	2.8	2.8	2.2	2.2	2.1
MM	1.5	2.1	1.9	1.3	1.8	1.2
ATM	1.6	1.7	2.0	1.4	1.8	1.3
TATM	1.6	1.4	1.9	1.3	1.5	1.3

Time to Inactivate ≥5 log CFU/cm² of Pathogens on Beef Jerky Dried at 60°C for 10 h and Stored at 25°C for 60 d (TSAP; initial inoculum: 7 log CFU/cm²)

Treatment	*Escherichia coli* O157:H7		*Salmonella*		*Listeria monocytogenes*	
	NA	AA	NA	AA	NA	AA
C	30d	30d	60d	30d	15d	30d
TM	30d	30d	>60d	15d	15d	15d
MM	15d	15d	30d	7h	7h	7h
ATM	15d	10h	30d	7h	7h	7h
TATM	15d	10h	15d	7h	7h	7h

Time for Beef Jerky Inoculated After Drying (60°C for 10 h) to to Reach ≥5 log CFU/cm² Inactivation During Aerobic Storage (25°C for 60d) (TSAP; initial inoculum: 7 log CFU/cm²)

Treatment	*E. coli* O157:H7		*Salmonella*		*Listeria monocytogene*	
	NA	AA	NA	AA	NA s	AA
C	>60d	42d	>60d	60d	>60d	60d
TM	>60d	42d	>60d	60d	60d	60d
MM	28d	14d	60d	28d	28d	28d
ATM	14d	7d	60d	14d	28d	28d
TATM	14d	7d	42d	14d	28d	28d

TABLE 1. *Parameter estimates (standard deviations) obtained by fitting survival data with the logistic Kamau et al. (15) equation (C, M) and piecewise linear regression (AM)*

Temp (°C)	Treatment	*f*	*a* $(h^{-1})^{a,c}$	*b* $(h^{-1})^{b,c}$
52	C	0.818 (0.101)	3.778 (0.447)	0.870 (0.118)
	M	0.918 (0.066)	2.400 (0.807)	0.591 (0.244)
57	C	0.944 (0.079)	2.968 (0.710)	0.533 (0.232)
	M	0.945 (0.095)	3.105 (0.986)	0.425 (0.192)
63	C	0.987 (0.014)	3.672 (0.991)	0.582 (0.237)
	M	0.983 (0.010)	3.562 (1.438)	0.702 (0.092)

Temp (°C)	Treatment	β_0	β_1 (log CFU/cm^2)^{a,c}	β_2	$(\beta_1 + \beta_2)$ (log CFU/cm^2)^{b,c}
52	AM	5.485 (0.163)	−2.463 (0.350)	2.298 (0.505)	−0.165
57	AM	5.485 (0.163)	−2.535 (0.177)	2.426 (0.216)	−0.110
63	AM	5.553 (0.079)	−2.524 (0.391)	2.750 (0.653)	−0.249

[a] Death rate of first phase.

[b] Death rate of second phase.

[c] Effect of drying temperature (within a column) was not significant ($P > 0.05$). C, control; M, traditional marination; AM, dipping into 5% acetic acid, followed by M; *f*, first phase of bacterial survival curves; *a*, *b*, death rates for the first and second phases of bacterial survival curves, respectively; β_0, intercept (initial bacterial populations); β_1, slope of the first phase in bacterial survival curves; β_2, differential effect in the slope in the negative direction from the point where the slope changes to zero; $\beta_1 + \beta_2$, slope of the second phase in bacterial survival curves.

Table 2

Mean (SD) log CFU/g[1] bacterial (SMAC: sorbitol MacConkey Agar; TSA: tryptic soy agar) populations on gala apple slices inoculated with *E. coli* O157:H7, exposed to various pre-drying treatments and dried at 62.8 °C (145°F)

Processing steps	Control[2]		Water[3]		AA[4]		CA[5]		LJ[6]		LJP[7]	
	SMAC	TSA	SMAC	TSA	SMAC	TSA	SMAC	TSA	SMAC	TSA	SMAC	TSA
Following inoculation[8]	7.8^{Aa} (0.4)	8.0^{Aa} (0.5)	7.8^{Aa} (0.2)	7.9^{Aa} (0.2)	7.8^{Aa} (0.4)	8.0^{Aa} (0.5)	7.8^{Aa} (0.4)	8.0^{Aa} (0.5)	7.8^{Aa} (0.4)	8.0^{Aa} (0.5)	7.8^{Aa} (0.4)	8.0^{Aa} (0.5)
Following pretreatment at 0 h	7.8^{Aab} (0.4)	8.0^{Aa} (0.5)	7.0^{ABabc} (0.1)	7.2^{ABabc} (0.2)	7.1^{Aabc} (0.5)	7.4^{Aabc} (0.3)	6.7^{Bc} (0.4)	6.9^{Bbc} (0.6)	7.0^{Aabc} (0.4)	7.1^{Aabc} (0.4)	6.6^{Bc} (0.7)	7.1^{Aabc} (0.2
Dehydration (2 h)	7.5^{Aa} (0.3)	7.8^{Aa} (0.3)	6.5^{Bbc} (0.3)	7.1^{ABab} (0.3)	5.6^{Bcd} (0.6)	5.9^{Bcd} (0.7)	4.4^{Ce} (0.5)	5.1^{Cde} (0.8)	4.8^{Be} (0.4)	5.6^{Bcd} (0.7)	4.4^{Ce} (0.7)	4.9^{Bde} (0.7)
Dehydration (3 h)	7.1^{Aa} (0.5)	7.4^{Aa} (0.4)	5.4^{Cbc} (0.3)	6.4^{Bab} (0.4)	3.5^{Cdef} (0.7)	4.3^{Cd} (0.9)	2.2^{Dg} (1.4)	3.8^{Dde} (0.9)	3.1^{Cefg} (1.6)	4.5^{Ccd} (0.9)	2.7^{Dfg} (0.7)	4.1^{Bde} (0.9)
Dehydration (4 h)	5.4^{Bab} (1.9)	5.6^{Ba} (1.1)	2.8^{Dc} (0.6)	4.5^{Cb} (0.6)	1.3^{Dde} (1.4)	3.0^{Dc} (1.1)	0.6^{Fe} (0.2)	1.4^{Ede} (0.7)	0.9^{De} (0.7)	2.1^{Dcd} (1.0)	1.3^{Ede} (0.3)	2.5^{Cc} (1.8)
Dehydration (6 h)	5.3^{Ba} (1.1)	4.9^{Ba} (0.9)	2.0^{Dbc} (0.1)	2.8^{Db} (0.4)	0.7^{Dd} (0.3)	1.3^{Ecd} (0.6)	0.6^{Ed} (0.2)	1.3^{Ecd} (1.0)	0.5^{Dd} (0.0)	0.9^{Ed} (1.1)	1.1^{Ecd} (0.1)	1.3^{Dcd} (1.1)

A–E means with different superscripts within a column are significantly different ($P<0.05$). a–g means with different superscripts within a row are significantly different ($P<0.05$)

[1] Means represent one sample in each of nine replications ($n=9$) (standard deviation) of log colony-forming units (CFU/g); Lowest detection limit by direct plating=0.5 log CFU/g (LSD=1.1 log CFU/g).

[2] Control, inoculated with no pretreatment.

[3] Dipped in sterile water (10 min) before drying.

[4] Dipped in ascorbic acid solution (10 min, 2.8%, pH 2.6).

[5] Dipped in citric acid solution (10 min, 1.7%, pH 2.2).

[6] Dipped in commercial lemon juice w/no preservatives (10 min, 50%, pH 2.5).

[7] Dipped in commercial lemon juice solution w/preservatives (10 min, 50%, pH 2.7).

[8] Following inoculation (30 min immersion, 25 °C).

TABLE 2. *Mean bacterial populations on Gala apple slices inoculated with* Salmonella *exposed to various predrying treatments, and dried for 6 h at 60°C (140°F)*[a]

Sampling time	Mean count (log CFU/g) for each treatment					
	Control[b]			Water[c]		
	TSAP	BGS	XLT4	TSAP	BGS	XLT4
Following inoculation[g]	7.6 (0.4) A a x	7.6 (0.2) A a x	7.2 (0.1) A a x	7.6 (0.4) A a x	7.6 (0.2) A a x	7.2 (0.1) A a x
Following pretreatment (0 h)	7.6 (0.4) A b x	7.6 (0.2) A b x	7.2 (0.1) A c x	7.4 (0.1) A ab xy	7.7 (0.4) A b y	6.8 (0.3) A bc x
After dehydration for 1.5 h	7.2 (0.3) A c y	6.8 (0.7) A c y	5.9 (0.6) B c x	6.8 (0.3) AB bc y	6.6 (0.4) B bc xy	5.8 (0.5) B c x
After dehydration for 3 h	6.3 (0.5) B c y	6.1 (0.5) A b y	5.0 (0.7) C b x	6.1 (0.6) B bc y	6.2 (0.3) B b y	5.2 (1.2) B b x
After dehydration for 4.5 h	5.4 (0.8) C c z	4.9 (0.3) B cd y	3.5 (0.3) D b x	5.0 (0.4) C c y	4.8 (0.4) C d y	3.6 (0.7) C b x
After dehydration for 6 h	4.8 (0.4) C c y	4.9 (0.3) B c y	3.0 (0.4) D b x	4.9 (0.3) C c y	4.7 (0.2) C c y	3.2 (0.8) C b x

[a] Means represent counts for two samples in each of three replications (BGS agar; $n = 6$) or five replications (XLT4 agar and TSAP; $n = 10$). Standard deviations are shown in parentheses. The detection limit was 1.1 log CFU/g (LSD, 0.8 log CFU/g). BGS, BG sulfa agar; XLT4, XLT4 agar; TSAP, tryptic soy agar supplemented with 0.1% pyruvate. Means with different small capital letters in the same column are significantly different ($P < 0.05$). Means with different lowercase letters (a through d) for the same medium in the same row are significantly different ($P < 0.05$). Means with different lowercase letters (x through z) for the same treatment in the same row are significantly different ($P < 0.05$).

[b] Apple slices were inoculated with no pretreatment for 30 min at 25°C.

[c] Apple slices were immersed in sterile water for 10 min at 25°C.

[d] Apple slices were immersed in a 4.18% sodium metabisulfite solution (pH 4.19) for 10 min at 25°C.

[e] Apple slices were immersed in a 3.40% ascorbic acid solution (pH 2.36) for 10 min at 25°C.

[f] Apple slices were immersed in a 0.21% citric acid solution (pH 2.48) for 10 min at 25°C.

[g] 30 min attachment time, 25°C.

TABLE 2. *Extended*

Mean count (log CFU/g) for each treatment								
Sodium metabisulfite[d]			Ascorbic acid[e]			Citric acid[f]		
TSAP	BGS	XLT4	TSAP	BGS	XLT4	TSAP	BGS	XLT4
7.6 (0.4) A a x	7.6 (0.2) A a x	7.2 (0.1) A a x	7.6 (0.4) A a x	7.6 (0.2) A a x	7.2 (0.1) A a x	7.6 (0.4) A a x	7.6 (0.2) A a x	7.2 (0.1) A a x
7.2 (0.3) A ab z	6.3 (0.6) B a y	1.8 (0.5) B a x	6.9 (0.2) A ab x	6.7 (0.2) B a x	6.3 (0.1) B b x	6.7 (0.2) B a x	6.5 (0.2) B a x	6.3 (0.1) B b x
6.1 (0.3) B ab y	5.8 (0.4) B b y	2.7 (0.4) C a x	5.8 (0.5) B a y	5.0 (0.6) C a y	4.1 (0.5) C b x	6.2 (0.4) B ab y	6.1 (0.5) B bc y	4.9 (0.7) C b x
5.0 (0.9) C a y	4.7 (1.2) C a y	2.8 (1.2) C a x	4.7 (0.6) C a y	4.1 (1.1) D a y	2.1 (1.0) D a x	5.4 (0.5) B ab y	4.8 (1.1) C a y	2.7 (1.2) D a x
3.9 (0.6) D b y	3.3 (0.4) D b y	1.6 (0.3) B a x	2.5 (1.0) D a y	2.3 (0.7) E a y	1.4 (0.2) D a x	4.0 (1.1) C b y	3.7 (0.7) D bc y	1.8 (0.4) E a x
3.3 (0.3) D b y	3.0 (1.1) D ab y	1.7 (0.6) B a x	2.4 (0.8) D a y	2.2 (0.7) E a xy	1.5 (0.2) D a x	3.8 (0.4) C b y	3.7 (0.6) D b y	1.6 (0.5) E a x

Table 2
Mean (log cfu/g[a]) bacterial (PALCAM) populations (SD[b]) on peach slices inoculated with *L. monocytogenes*, exposed to various pre-drying treatments, dried for 6 h at 60°C (140°F) and stored for up to 14 d at 25±2°C

Processing steps	Control[c]	Water[d]	Sodium metabisulfite[e]	Ascorbic acid[f]	Citric acid[g]
Following inoculation[h]	7.74Aa (0.09)	7.74Aa (0.09)	7.74Aa (0.09)	7.74Aa (0.09)	7.74Aa (0.09)
Following dehydration[I] (0 d)	4.82Bb (0.46)	4.21Bb (0.36)	2.37Ba (0.89)	1.34Ba (0.16)	2.13Ba (0.39)
Following storage (7 d)	3.80Bb (0.56)	2.66Cab (1.63)	2.14Ba (1.14)	1.38Ba (0.09)	2.65Bab (1.64)
Following storage (14 d)	1.84Ca (0.65)	1.81Ca (0.54)	1.44Ba (0.05)	<1.10[j]	<1.10[j]

TABLE 4. *Bacterial populations recovered on tryptic soy agar plus 0.1% pyruvate from peeled-unblanched and peeled-blanched Roma tomato halves*

Analysis[a]	Mean (SD) counts (log CFU/g) by treatment[b]			
	Control	Water	Ascorbic acid	Citric acid
Unblanched				
After inoculation	7.4 (0.3) AZ	7.4 (0.3) AZ	7.4 (0.3) AZ	7.4 (0.3) AZ
After immersion (0 h)	7.4 (0.3) AZ	6.4 (0.4) BY	6.1 (0.3) BY	5.9 (0.3) BY
Dehydration				
4 h	7.1 (0.3) AZ	6.2 (0.4) BY	5.9 (0.3) BY	5.8 (0.4) BCY
8 h	5.9 (0.8) BZ	5.3 (0.3) CZ	4.1 (0.5) DY	4.4 (0.5) DY
12 h	4.1 (1.1) CZ	3.5 (0.5) EFY	2.1 (0.7) EX	2.5 (0.7) FGX
14 h	3.8 (0.3) CZ	3.0 (0.9) FGY	1.7 (0.5) EX	2.1 (0.5) IIX
Storage				
7 days	2.8 (0.3) DZ	2.2 (0.6) HIZY	<1.3 FX[c]	1.8 (0.5) HY
14 days	2.1 (0.3) DEZ	2.2 (0.3) HIZ	<1.3 FX[c]	1.7 (0.4) HY
21 days	2.1 (0.3) DEZ	2.2 (0.2) HIZ	<1.3 FY[c]	<1.3 IY[c]
28 days	1.8 (0.3) EZ	2.1 (0.4) IZ	<1.3 FY[c]	<1.3 IY[c]
Blanched				
After inoculation	7.4 (0.1) AZ	7.4 (0.1) AZ	7.4 (0.1) AZ	7.4 (0.1) AZ
After immersion (0 h)	7.4 (0.1) AZ	6.7 (0.3) BY	6.2 (0.4) BY	6.4 (0.4) BY
Dehydration				
4 h	6.9 (0.4) AZ	6.6 (0.3) BZY	6.0 (0.7) BX	6.2 (0.5) BXY
8 h	6.3 (1.0) BZ	6.3 (0.5) BZ	5.0 (0.4) CY	5.4 (0.6) CY
12 h	4.3 (0.9) CZ	4.2 (0.9) DZY	2.0 (0.7) EX	3.7 (0.7) EY
14 h	4.1 (0.3) CZ	3.7 (0.6) DEZ	<1.5 FX	2.9 (0.2) FY
Storage				
7 days	2.8 (0.2) DZ	3.0 (0.2) FGZ	<1.4 FX[c]	2.1 (0.6) GHY
14 days	2.7 (0.3) DZ	2.8 (0.3) GZ	<1.4 FX[c]	2.0 (0.6) GHY
21 days	2.5 (0.3) DZ	2.7 (0.4) GHZ	<1.3 FX[c]	1.9 (0.6) HY
28 days	2.1 (0.3) DEZY	2.7 (0.4) GHZ	<1.3 FW[c]	1.7 (0.4) HIX

[a] Tomato halves were inoculated with a five-strain mixture of *Salmonella*, exposed to various predrying treatments, dried at 60°C for 14 h, and stored at 25°C for 28 days.

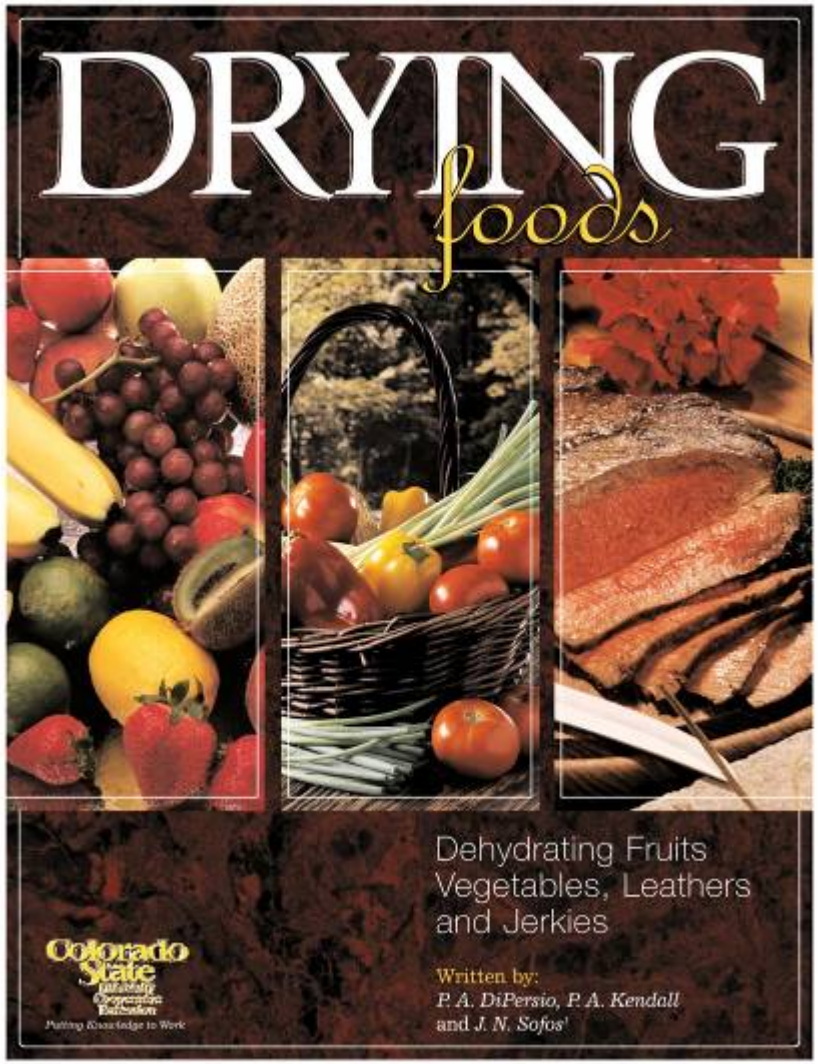
[b] Means within a column that lack a common letter (A through I) are significantly different ($P < 0.05$). Means within a row that lack a common letter (W through Z) are significantly different ($P < 0.05$). Ascorbic acid: 3.40%, pH 2.48; citric acid: 0.21%, pH 2.51.

[c] Negative for *Salmonella* by enrichment.

FOOD SAFETY EDUCATION

Drying Foods Workshops:

Date	Location
4/07/04	Larimer County
4/08/04	Weld County
4/28/04	Colorado Springs
6/02/04	Adams County
7/15/04	Alamosa County
7/30/04	Larimer County
8/06/04	Douglas County



OUTCOMES

- **Student Training:**
  - Six Master of Science thesis projects and two PhD dissertations, trained in food microbiology and food safety education. These include:
    - Patricia DiPersio. Summer 2005. Improving the Safety of Home-Dried Foods through Modification of Treatments and Educational Programs. PhD Dissertation. (working for the retail industry)
    - Yohan Yoon. Summer 2003. Inactivating pathogens in tomatoes and beef jerky. M.S. Thesis (completing PhD)
    - Sumanpriya Lakkakula. Fall 2002. Inactivation of *Escherichia coli* O157:H7 During Drying of Apple Slices Previously Treated with Citric Acid. M.S. Thesis. (continued for PhD)

OUTCOMES

- Patricia DiPersio. Summer 2002. Inactivation of *Salmonella* and *Listeria monocytogenes* during Drying and Storage of Apple and Peach Slices Treated with Acidic or Sodium Metabisulfite Solutions. M.S. Thesis. (completed PhD and now working for the retail industry)
- Elizabeth Lee Derrickson-Tharrington. Fall 2001. Evaluation of Common Acidulants for Enhancement of Destruction of *Escherichia coli* O157:H7 during Drying of Gala Apple Slices and Whole Muscle Beef Jerky. M.S. Thesis. (working for the meat industry)
- Jennifer Burnham. Spring 2000. Survival of *Escherichia coli* O157:H7 During Home-type Drying of Apple Slices. M.S. Thesis. (working for FDA)

OUTCOMES

- **The following scientists worked as postdoctoral fellows** at different times during the life of the project (their current affiliations are shown in parentheses):
  - Samelis, John (Scientist, National Agricultural Research Foundation of Greece).
  - Ikeda, Jack (Scientist, University of Illinois, Urbana-Champaign).
  - Calicioglu, Mehmet (Faculty member at Firat University in Turkey).
  - Koutsoumanis, Kostas (Faculty member at the Aristotle Ubiversity of Thessaloniki, Greece).
  - Georgnaras, Gina (Research Associate, Colorado State University).
  - Skandamis, Panagiotis (Faculty member at Agricultural University of Athens, Greece).

OUTCOMES

- **Posters or oral presentations at professional meetings:**
  - Albright, S.N., J.N. Sofos, and P.A. Kendall. 2000. Survival of inoculated *Escherichia coli* O157:H7 on beef jerky dried at 62.5°C following four preparation treatments. 87th IAFP Meeting, August 6-9, Atlanta, GA. Abstract No. P025.
  - Albright, S.N., P.A. Kendall, and J.N. Sofos. 2000. Sensory properties of beef jerky processed under various conditions. 60th IFT Meeting, June 10-14, Dallas, TX. Abstract No. 11-1.
  - Albright, S.N., J.N. Sofos, P.A. Kendall, and G.R Schmidt. 2000. Survival of *Escherichia coli* in marinated beef jerky dried at two temperatures. 60th IFT Meeting, June 10-14, Dallas, TX. Abstract No. 34-4.
  - Burnham, J.A., P.A. Kendall, and J.N. Sofos. 2000. Survival of *Escherichia coli* O157:H7 on home-dehydrated apple slices. 60th IFT Meeting, June 10-14, Dallas, TX. Abstract No. 51H-14.

OUTCOMES

- Albright, S.N., J.S. Avens, A.S. Morton, B.E. Prewitt, P.A. Kendall, and , J.N. Sofos. 2000. Destruction of bacteria on chicken carcasses by steam and boiling water immersion. Food Safety Objectives: Public Health, HACCP and Science Conference Abstract Book. Poster No. 33, p. 55.
- Derrickson, E.L., P.A. Kendall, and J.N. Sofos. 2001. Survival of *Escherichia coli* O157:H7 on apple slices treated with acidic solutions. 61st IFT Meeting, June 23-26, New Orleans, LA. Abstract No. 59E-6.
- Derrickson, E.L., P.A. Kendall, and J.N. Sofos. 2001. Destruction of *Escherichia coli* O157:H7 in beef jerky exposed to acidified marinades before drying. 61st IFT Meeting, June 23-26, New Orleans, LA. Abstract No. 59E-7.

OUTCOMES

- Lakkakula, S., P.A. Kendall, J. Samelis, and J.N. Sofos. 2001. Destruction of *Escherichia coli* O157:H7 on apples of different varieties treated with citric acid before drying. 88th IAFP Meeting, August 5-8, Minneapolis, MN. Abstract No. PO32.
- Derrickson, E.L., P.A. Kendall, and J.N. Sofos. 2001. Destruction of *Escherichia coli* O157:H7 during drying of apple slices pre-treated with acidic solutions after inoculation. 88th IAFP Meeting, August 5-8, Minneapolis, MN. Abstract No. PO33.
- Abushelaibi, A.A., J. Samelis, P.A. Kendall, and J.N. Sofos. 2001. Survival and growth of *Salmonella* in reconstituted infant cereal hydrated with water, milk or apple juice. 88th IAFP Meeting, August 5-8, Minneapolis, MN. Abstract No. PO95.

OUTCOMES

- Calicioglu, M., J.N. Sofos, J. Samelis, and P.A. Kendall. 2002. Influence of marinades on survival during storage at 25°C of acid-adapted and nonadapted *Escherichia coli* O157:H7 inoculated post-drying on beef jerky. 62nd IFT Meeting, June 15-19. Anaheim, CA. Abstrast No. 76B-8.
- DiPersio, P., P.A. Kendall, M. Calicioglu, and J.N. Sofos. 2002. Destruction of *Listeria monocytogenes* during drying and storage of peaches treated with acid or sodium metabisulfite solutions. 62nd IFT Meeting, June 15-19. Anaheim, CA. Abstrast No. 15D-13.
- Abushelaibi, A., J. Samelis, P. Kendall, and J.N. Sofos. 2002. Survival and growth of *Listeria monocytogenes* in stored (4, 15 or 25°C) infant cereals hydrated with water, milk or apple juice. 89th IAFP Meeting, June 30-July 3, San Diego, CA. Abstract No. P54.

OUTCOMES

- Yoon, Y., P.A. Kendall, and J.N. Sofos. 2002. Inactivation of *Salmonella* during drying of Roma tomatoes treated with organic acids. 89th IAFP Meeting, June 30-July 3, San Diego, CA. Abstract No. P95.
- DiPersio, P., P.A. Kendall, M. Calicioglu, and J.N. Sofos. 2002. Inactivation of *Salmonella* during drying and storage of Gala apples treated with acid or sodium metabisulfite solutions. 89th IAFP Meeting, June 30-July 3, San Diego, CA. Abstract No. P103.
- Lakkakula, S.P., P.A. Kendall, J. Samelis, and J.N. Sofos. 2002. Effect of acid adaptation on inactivation of *Echerichia coli* O157:H7 during drying of apple slices. 89th IAFP Meeting, June 30-July 3, San Diego, CA. Abstract No. P108.

OUTCOMES

- Ikeda, J., J.D. Stopforth, P.A. Kendall, and J.N. Sofos. 2002. Survival of acid-adapted or nonadapted *Escherichia coli* O157:H7 in apple wounds following chemical treatments and storage of samples. 89th IAFP Meeting, June 30-July 3, San Diego, CA. Abstract No. P167.
- Calicioglu, M., J.N. Sofos, J Samelis, and P.A. Kendall. 2002. Effect of acid adaptation on destruction of *Salmonella* during drying (60oC) and storage (25oC) of beef jerky treated with marinades. 89th IAFP Meeting, June 30-July 3, San Diego, CA. Abstract No. P180.
- Calicioglu, M., J.N. Sofos, J Samelis and P.A. Kendall. 2002. Influence of marinades on survival during storage at 25°C of acid-adapted and nonadapted *Listeria monocytogenes* and *Salmonella* inoculated post-drying on beef jerky. 89th IAFP Meeting, June 30-July 3, San Diego, CA. Abstract No. P181.

OUTCOMES

- Calicioglu, M, J.N. Sofos, J. Samelis, and P.A. Kendall. 2002. Inactivation of acid-adapted and nonadapted *Escherichia coli* O157:H7 during drying (60°C) and storage (25°C) of beef jerky strips previously treated with various marinades. 102nd ASM Meeting, May 19-23, Salt lake City, UT. Abstrast No. P-23.
- Calicioglu, M., J.N. Sofos, J. Samelis, P.A. Kendall. 2002. Inactivation of acid-adapted and nonadapted *Escherichia coli* O157:H7 during drying (60°C) and storage (25°C) of beef jerky previously treated with marinades. Poster presentation. Cooperative Extension February In-service, Colorado State University, Fort Collins, CO, February 27.
- Calicioglu, M. J.N. Sofos, J. Samelis, P.A. Kendall, and G.C. Smith. 2002. Effect of marinades on survival of acid-adapted and nonadapted *Listeria monocytogenes* on beef jerky. 48th Int. Congress of Meat Science and Technology. Rome, Italy, August 25-30. Abstract.

OUTCOMES

- Yoon, Y., P.A. Kendall, G.C. Smith, and J.N. Sofos. 2003. Influence of inoculum level and acidic marination on inactivation of *Escherichia coli* O157:H7 during drying and storage of beef jerky. 90th IAFP Meeting, August 10-13, New Orleans, LA. Abstract No. P155.
- Koutsoumanis, K.P., P.A. Kendall, and J.N. Sofos. 2003. Development and evaluation of a mathematical model for the effect of temperature, pH, NaCl and sodium lactate on the surface growth limits of *Listeria monocytogenes*. 90th IAFP Meeting, August 10-13, New Orleans, LA. Abstract No. P173.
- Koutsoumanis, K.P., P.A. Kendall, and J.N. Sofos. 2003. Effect of inoculum size on the growth/no growth boundary of *Listeria monocytogenes*. 90th IAFP Meeting, August 10-13, New Orleans, LA. Abstract No. T54.

OUTCOMES

- Koutsoumanis, K., P.A. Kendall, and J.N. Sofos. 2003. Acid tolerance of *Listeria monocytogenes* as affected by environmental stresses related to food processing technologies. 63rd IFT Meeting, July 12-16, Chicago, IL. Abstract No. 29G-1.
- Koutsoumanis, K., P.A. Kendall, and J.N. Sofos. 2003. Development and evaluation of a growth/no growth interface model for *Salmonella* Typhimurium as a function of temperature, water activity and pH. 63rd IFT Meeting, July 12-16, Chicago, IL. Abstract No. 76E-5.
- DiPersio, P.A., P.A. Kendall, M. Calicioglu and J.N. Sofos. 2003. Inactivation of *Salmonella* during drying and storage of Gala apples treated with acid or sodium metabisulfite solutions. Poster presentation. Cooperative Extension February In-service, Colorado State University, Fort Collins, CO, February 26.

OUTCOMES

- Koutsoumanis, K.P., Kendall, P.A., Sofos, J.N. 2003. Modeling liquid and surface growth limits of *Listeria monocytogenes* as a function of pH, water activity and temperature. 90th IAFP Meeting, New Orleans, LA, August 10-13, 2003. Abstract P048.
- Dipersio, P.A., P.A. Kendall, and J.N. Sofos. 2003. Consumer acceptance of peach quarters and slices treated with antimicrobial solutions before home-type dehydration. 63rd IFT Meeting, July 12-16, Chicago, IL. Abstract No. 104D-5.
- Sofos, J.N., Y. Yoon, P.A. DiPersio, and P.A. Kendall. 2004. Inactivation of *Salmonella* during drying of Nantes carrot slices treated with blanching or immersion in 3.23% NaCl before drying, or oven heating after drying. 64th IFT Meeting, July 12-16, Las Vegas, NV. Abstract No. 114C-8.

OUTCOMES

- Skandamis, P.N., Y. Yoon, G.C. Smith, J.N. Sofos, and P.A. Kendall. 2004. Modeling the effect of marination and temperature on inactivation of *Escherichia coli* O157:H7 during drying of beef jerky. 64th IFT Meeting, July 12-16, Las Vegas, NV. Abstract No. 67E-13.
- Skandamis, P.N., Y. Yoon, J.D. Stopforth, J.N. Sofos, and P.A. Kendall. 2004. Heat and acid tolerance of *Listeria monocytogenes* after exposure to sequential or simultaneous sublethal stresses. 64th IFT Meeting, July 12-16, Las Vegas, NV. Abstract No. 99D-7.
- Skandamis, P.N., J.D. Stopforth, J.N. Sofos, and P.A. Kendall. 2004. Modeling of the effect of inoculum size and acid adaptation on growth/no growth interface of *Escherichia coli* O157:H7. 64th IFT Meeting, July 12-16, Las Vegas, NV. Abstract No. 114D-6.

OUTCOMES

- DiPersio, P.A., P.A. Kendall, Y. Yoon, and J.N. Sofos. 2004. Inactivation of *Salmonella* during drying and storage of Nantes carrot slices treated with steam, water or acid blanching before dehydration. 91st IAFP Meeting, August 8-11, Phoenix, AZ. Abstract No. P217.
- Skandamis, P.N., J.D. Stopforth, L.V. Ashton, I. Geornaras, P.A. Kendall and J.N. Sofos. 2004. Effect of drying on survival and acid tolerance of *Escherichia coli* O157:H7 biofilms formed in beef decontamination runoff fluids. 91st IAFP Meeting, August 8-11, Phoenix, AZ. Abstract No. P164.
- Skandamis, P.N., Y. Yoon, J.D. Stopforth, P.A. Kendall, and J.N. Sofos. 2004. Modeling the effect of aerobic and anaerobic storage on growth/no growth interface of *Listeria monocytogenes* as a function of temperature, sodium lactate, sodium diacetate and NaCl. 91st IAFP Meeting, August 8-11, Phoenix, AZ. Abstract No. P118.

OUTCOMES

- Skandamis, P.N., J.D. Stopforth, Y. Yoon, I. Geornaras, P.A. Kendall, and J.N. Sofos. 2004. Heat and acid tolerance response of *Listeria monocytogenes* as affected by sequential exposure to hurdles during growth. 91st IAFP Meeting, August 8-11, Phoenix, AZ. Abstract No. P178.
- Yoon, Y., P.N. Skandamis, P.A. Kendall, G.C. Smith, and J.N. Sofos. 2004. A predictive model to determine the effect of drying temperature and marination in reducing *Listeria monocytogenes* population during drying of beef jerky. 91st IAFP Meeting, August 8-11, Phoenix, AZ. Abstract No. P117.
- Yoon, Y., P. N. Skandamis, P. A. Kendall, G. C. Smith, and J. N. Sofos. 2005. Modeling the effect of drying temperature and marination for reducing *Salmonella* population during drying of beef jerky. 65th IFT Meeting, July 15-20, New Orleans, LA. Abstract No. 89E-22.

OUTCOMES

- DiPersio, P.A., Kendall, P.A., Sofos, J.N. 2005. Food drying workshops promote safe home drying. J. Nutrition Educ. Behavior, Abstract P22. 37[Suppl 1]:S57.
- DiPersio, P. A., P. A. Kendall, Y. Yoon, and J. N. Sofos. 2005. Inactivation of *Salmonella* during and storage of carrot slices treated with steam, water or acid blanching before dehydration. 65th IFT Meeting, July 15-20, New Orleans, LA. Abstract No. 89E-20.
- DiPersio, P. A., P. A. Kendall, Y. Yoon, and J. N. Sofos. 2005. Influence of blanching treatments on *Salmonella* during home-type dehydration and storage of potato slices. 92st IAFP Meeting, August 14-17, Baltimore, MD. Abstract No. P3-23.

OUTCOMES

- **Referred Journal Papers:**
  - Burnham, J.A., P.A. Kendall, and J.N. Sofos. 2001. Ascorbic acid enhances destruction of *Escherichia coli* O157:H7 during home-type drying of apple slices. J. Food Prot. 64:1244-1248.
  - Albright, S.N., P.A. Kendall, J.S. Avens, and J.N. Sofos. 2002. Effect of marinade and drying on inactivation of *Escherichia coli* O157:H7 on inoculated home dried beef jerky. J. Food Safety 155-167.
  - Calicioglu, M., J.N. Sofos, J. Samelis, P.A. Kendall, and G.C. Smith. 2002. Inactivation of acid-adapted and nonadapted *Escherichia coli* O157:H7 during drying and storage of beef jerky treated with different marinades. J. Food Prot. 65:1394-1405.
  - Calicioglu, M., J.N. Sofos, J. Samelis, P.A. Kendall, and G.C. Smith. 2002. Destruction of acid- and non-adapted *Listeria monocytogenes* during drying and storage of beef jerky. Food Microbiol. 19:545-559.

OUTCOMES

- Abushelaibi, A.A., J.N. Sofos, J. Samelis, and P.A. Kendall. 2003. Survival and growth of *Salmonella* in reconstituted infant cereal hydrated with water, milk or apple juice and stored at 4oC, 15oC and 25oC. Food Microbiol. 20:17-25.
- Calicioglu, M., J.N. Sofos, and P.A. Kendall. 2003. Fate of acid-adapted and non-adapted *Escherichia coli* O157:H7 inoculated post-drying on beef jerky treated with marinades before drying. Food Microbiol. 20:169-177.
- Calicioglu, M., J.N. Sofos, P.A. Kendall, and G.C. Smith. 2003. Effects of acid adaptation and modified marinades on survival of postdrying *Salmonella* contamination on beef jerky during storage. J. Food Prot. 66:396-402.
- Calicioglu, M., J.N. Sofos, and P.A. Kendall. 2003. Influence of marinades on survival during storage of acid-adapted and nonadapted *Listeria monocytogenes* inoculated post-processing on beef jerky. Int. J. Food Microbiol. 86:283-292.

OUTCOMES

- Albright, S.N., P.A. Kendall, J.S. Avens, and J.N. Sofos. 2003. Pretreatment effect on inactivation of *Escherichia coli* O157:H7 inoculated beef jerky. Lebensm. Wissensch. und Technol. 36:381-389.
- Calicioglu, M., J.N. Sofos, J. Samelis, P.A. Kendall, and G.C. Smith. 2003. Effect of acid adaptation on inactivation of *Salmonella* during drying and storage of beef jerky treated with marinades. Int. J. Food Microbiol. 89:51-65.
- Abushelaibi, A.A., J.N. Sofos, J. Samelis, and P.A. Kendall. 2003. Behavior of *Listeria monocytogenes* in reconstituted infant cereals. J. Food Saf. 23:147-158.
- DiPersio, P.A., P.A. Kendall, M. Calicioglu, and J.N. Sofos. 2003. Inactivation of *Salmonella* during drying and storage of apple slices treated with acidic or sodium metabisulfite solutions. J. Food Prot. 66:2245-2251.

OUTCOMES

- Koutsoumanis, K.P., P.A. Kendall, and J.N. Sofos. 2003. Effect of food processing-related stresses on acid tolerance of *Listeria monocytogenes*. Appl. Environ. Microbiol. 69:7514-7516.
- Stopforth, J.D., J.S. Ikeda, P.A. Kendall, and J.N. Sofos. 2004. Survival of acid-adapted or nonadapted *Escherichia coli* O157:H7 in apple wounds and surrounding tissue following chemical treatments and storage. Int. J. Food Microbiol. 90:51-61.
- Koutsoumanis, K.P., P.A. Kendall, and J.N. Sofos. 2004. Modeling the boundaries of growth of *Salmonella* Typhimurium in broth as a function of temperature, water activity, and pH. J. Food Prot. 67:53-59.
- Koutsoumanis, K.P. and J.N. Sofos. 2004. Comparative acid stress response of *Listeria monocytogenes*, *Escherichia coli* O157:H7 and *Salmonella* Typhimurium after habituation at different pH conditions. Lett. Appl. Microbiol. 38:321-326.

OUTCOMES

- DiPersio, P.A., P.A. Kendall, and J.N. Sofos. 2004. Inactivation of *Listeria monocytogenes* during drying and storage of peach slices treated with acidic or sodium metabisulfite solutions. Food Microbiol. 21:641-648.
- Yoon, Y., J.D. Stopforth, P.A. Kendall, and J.N. Sofos. 2004. Inactivation of *Salmonella* during drying of Roma tomatoes exposed to predrying treatments including peeling, blanching, and dipping in organic acid solutions. J. Food Prot. 67:1344-1352.
- Nummer, B.A., J.A. Harrison, M.A. Harrison, P.A. Kendall, J.N. Sofos, and E.L. Andress. 2004. Effects of preparation methods on the microbiological safety of home-dried meat jerky. J. Food Prot. 67:2337-2341.
- Yoon, Y., M. Calicioglu, P.A. Kendall, G.C. Smith, and J.N. Sofos. 2005. Influence of inoculum level and acidic marination on inactivation of *Escherichia coli* O157:H7 during drying and storage of beef jerky. Food Microbiol. 22:423-431.

OUTCOMES

- Derrickson-Tharrington, E., P.A. Kendall, and J.N. Sofos. 2005. Inactivation of *Escherichia coli* O157:H7 during storage or drying of apple slices pretreated with acidic solutions. Int. J. Food Microbiol. 99:79-89.
- DiPersio, P.A., Y. Yoon, J.N. Sofos, and P.A. Kendall. 2005. Inactivation of *Salmonella* during drying and storage of carrot slices prepared using commonly recommended methods. J. Food Sci. 70:M230-M235.
- DiPersio, P.A., Y. Yoon, J.N. Sofos, and P.A. Kendall. 2005. Influence of blanching treatments on *Salmonella* during home-type dehydration and storage of potato slices. J. Food Prot. 68:2587-2593.
- Yoon, Y., P.N. Skandamis, P.A. Kendall, G.C. Smith, and J.N. Sofos. 2006. A predictive model for the effect of temperature and predrying treatments in reducing L*isteria monocytogenes* populations during drying of beef sausage. J. Food Prot. 69:62-70.

OUTCOMES

- DiPersio, P.A., Kendall, P.A., Sofos, J.N. 2006. Sensory evaluation of home dried fruit prepared using treatments that enhance destruction of pathogenic bacteria. J Food Quality 29:47-64.
- DiPersio, P.A., Sofos, J.N., Kendall, P.A. 2006. Food drying workshops promote safe home drying methods. Food Protection Trends 26:165-173.

OUTCOMES

- We developed several research reports, fact sheets, newsletter articles, columns, one bulletin and one correspondence course during the project. These include:
  - DiPersio, P.A., Kendall, P.A., and Sofos, J.N. 2004. Drying foods: dehydrating fruits, vegetables, leathers and jerkies. Colorado State University Cooperative Extension Bulletin No. 575A. Colorado State University, Fort Collins, CO. 20 p.
  - Kendall, P.A., DiPersio, P.A., and Sofos, J.N. Drying vegetables. 2004. CSU Cooperative Extension Fact Sheet No. 9.308. Colorado State University, Fort Collins, CO.
  - Kendall, P. and Sofos, J.N. 2003. Leathers and jerkies--dried food specialties. 2003. Food and Nutrition Series Fact Sheet #9.311, CSU Cooperative Extension, Fort Collins, CO.

OUTCOMES

- Kendall, P. and Sofos, J.N. 2003. Drying fruits. Food and Nutrition Series Fact Sheet #9.309, CSU Cooperative Extension, Fort Collins, CO.
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- Kendall, P. 2003. Food Storage for Safety and Quality. Colorado State University Cooperative Extension Fact Sheet No. 9.310. Colorado State University, Fort Collins, CO
- Kendall, P. 2000. New recommendations for jerky preparation. News release sent to 22 newspapers in Colorado. Oct 15, 2000.
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- Calicioglu, M., J.N. Sofos, J. Samelis, P.A. Kendall, and G.C. Smith. 2002. *Listeria monocytogenes* destruction during drying and storage of beef jerky treated with marinades. pp. 85-87. Animal Sciences Research Report, Department of Animal Sciences, Colorado State University, Fort Collins, CO.

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- Yoon, Y., P.N. Skandamis, P.A. Kendall, G.C. Smith, and J.N. Sofos. 2004. Effect of drying temperature and marination in reducing *Listeria monocytogenes* on beef jerky. Animal Sciences Research Report, Department of Animal Sciences, Colorado State University, Fort Collins, CO. 4 p.
- Yoon, Y., P.A. Kendall, G.C. Smith, and J.N. Sofos. 2005. Development of models to evaluate the effect of beef jerky drying temperature and marination against *Salmonella*. 5 p. Animal Sciences Research Report, Department of Animal Sciences, Colorado State University, Fort Collins, CO.